Claims

1. An ion detector for use in a mass spectrometer, said ion detector comprising:

one or more microchannel plates, wherein in use ions are received at an input surface of said one or more microchannel plates and electrons are released from an output surface of said one or more microchannel plates; and

an anode having a surface upon which electrons are received in use;

wherein said ion detector further comprises:

one or more electrodes and/or one or more magnetic lenses which, in use, direct, guide or attract at least some of said electrons released from said output surface of said one or more microchannel plates onto said anode; and

wherein said output surface of said one or more microchannel plates has a first area and said surface of said anode has a second area, wherein said second area is ≥ 5% of said first area.

2. An ion detector as claimed in claim 1, wherein said one or more electrodes and/or said one or more magnetic lenses are arranged between said one or more microchannel plates and said anode.

3. An ion detector as claimed in claim 1, wherein said one or more electrodes and/or said one or more magnetic

lenses are arranged so as to surround at least a portion of said anode.

4. An ion detector as claimed in claim 1, wherein said one or more magnetic lenses comprises one or more electro-magnets and/or one or more permanent magnets.

5. An ion detector as claimed in claim 1, wherein said anode is made from a non-magnetic material.

6. An ion detector as claimed in claim 1, wherein said anode is made from a soft (low coercivity) magnetic material.

7. An ion detector as claimed in claim 1, wherein said anode is made from a hard or permanent (high coercivity) magnetic material.

8. An ion detector as claimed in claim 1, wherein said second area is 5-90% of said first area.

9. An ion detector as claimed in claim 8, wherein said second area is ≤ 85%, ≤ 75%, ≤ 70%, ≤ 65%, ≤ 60%, ≤ 55%, ≤ 50%, ≤ 45%, ≤ 40%, ≤ 35% or ≤ 30% of said first area.

10. An ion detector as claimed in claim 8, wherein said second area is ≤ 25%, ≤ 20%, ≤ 15%, or ≤ 10% of said first area.

11. An ion detector as claimed in claim 8, wherein said second area is ≥ 10%, ≥ 15%, ≥ 20% or ≥ 25% of said first area.

12. An ion detector as claimed in claim 8, wherein said second area is ≥ 30%, ≥ 35%, ≥ 40%, ≥ 45%, ≥ 50%, ≥ 55%, ≥ 60%, ≥ 65%, ≥ 70%, ≥ 75%, ≥ 80% or ≥ 85% of said first area.

13. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more ring lenses.

14. An ion detector as claimed in claim 1, wherein said one or more electrodes have a thickness selected from the group consisting of: (i) ≤ 1.5 mm; (ii) ≤ 1.0 mm; and (iii) ≤ 0.5 mm.

15. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more Einzel lens arrangements comprising three or more electrodes.

16. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more segmented rod sets.

17. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more tubular electrodes.

18. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more quadrupole rod sets.

19. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise a plurality of electrodes having apertures through which electrons are

transmitted in use, said apertures having substantially the same area.

20. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise a plurality of electrodes having apertures through which electrons are transmitted in use, said apertures becoming progressively smaller or larger in a direction towards said anode.

21. An ion detector for use in a mass spectrometer, said ion detector comprising:

one or more microchannel plates, wherein in use ions are received at an input surface of said one or more microchannel plates and electrons are released from an output surface of said one or more microchannel plates; and

an anode having a surface upon which electrons are received in use;

wherein said ion detector further comprises:

one or more electro-magnets and/or one or more permanent magnets which, in use, direct or guide at least some of said electrons released from said output surface of said one or more microchannel plates onto said anode.

22. An ion detector for use in a mass spectrometer, said ion detector comprising:

one or more microchannel plates, wherein in use ions are received at an input surface of said one or more microchannel plates and electrons are released from an output surface of said one or more microchannel plates; and

an anode having a surface upon which electrons are received in use;

wherein said ion detector further comprises:

a plurality of electrodes and/or one or more magnetic lenses which, in use, direct, guide or attract at least some of said electrons released from said output surface of said one or more microchannel plates onto said anode, wherein said output surface of said one or more microchannel plates has a first area and said surface of said anode has a second area.

23. An ion detector as claimed in claim 22, wherein said plurality of electrodes and/or said one or more magnetic lenses are arranged between said one or more microchannel plates and said anode.

24. An ion detector as claimed in claim 22, wherein said plurality of electrodes and/or said one or more magnetic lenses are arranged so as to surround at least a portion of said anode.

25. An ion detector as claimed in claim 22, wherein said one or more magnetic lenses comprises one or more electro-magnets and/or one or more permanent magnets.

26. An ion detector as claimed in claim 22, wherein said anode is made from a non-magnetic material.

27. An ion detector as claimed in claim 22, wherein said anode is made from a soft (low coercivity) magnetic material.

28. An ion detector as claimed in claim 22, wherein said anode is made from a hard or permanent (high coercivity) magnetic material.

29. An ion detector as claimed in claim 22, wherein said second area is 5-90% of said first area.

30. An ion detector as claimed in claim 29, wherein said second area is ≤ 85%, ≤ 75%, ≤ 70%, ≤ 65%, ≤ 60%, ≤ 55%, ≤ 50%, ≤ 45%, ≤ 40%, ≤ 35% or ≤ 30% of said first area.

31. An ion detector as claimed in claim 29, wherein said second area is ≤ 25%, ≤ 20%, ≤ 15%, or ≤ 10% of said first area.

32. An ion detector as claimed in claim 29, wherein said second area is ≥ 10%, ≥ 15%, ≥ 20% or ≥ 25% of said first area.

33. An ion detector as claimed in claim 29, wherein said second area is ≥ 30%, ≥ 35%, ≥ 40%, ≥ 45%, ≥ 50%, ≥ 55%, ≥ 60%, ≥ 65%, ≥ 70%, ≥ 75%, ≥ 80% or ≥ 85% of said first area.

34. An ion detector as claimed in claim 22, wherein said anode comprises a pin anode.

35. An ion detector as claimed in claim 22, wherein said plurality electrodes comprises a plurality of ring lenses.

36. An ion detector as claimed in claim 22, wherein said plurality of electrodes each have a thickness selected from the group consisting of: (i) ≤ 1.5 mm; (ii) ≤ 1.0 mm; and (iii) ≤ 0.5 mm.

37. An ion detector as claimed in claim 22, wherein said plurality of electrodes comprise one or more Einzel lens arrangements comprising three or more electrodes.

38. An ion detector as claimed in claim 22, wherein said plurality of electrodes comprise one or more segmented rod sets.

39. An ion detector as claimed in claim 22, wherein said plurality of electrodes comprise a plurality of tubular electrodes.

40. An ion detector as claimed in claim 22, wherein said plurality of electrodes comprise one or more quadrupole rod sets.

41. An ion detector as claimed in claim 22, wherein said plurality of electrodes have apertures through which electrons are transmitted in use, said apertures having substantially the same area.

42. An ion detector as claimed in claim 22, wherein said plurality of electrodes have apertures through which electrons are transmitted in use, said apertures becoming progressively smaller or larger in a direction towards said anode.

43. An ion detector as claimed in claim 1, wherein in use said output surface of said one or more microchannel plates is maintained at a first potential, said surface of said anode is maintained at a second potential and said one or more of said electrodes and/or said one or more magnetic lenses are maintained at a third potential.

44. An ion detector as claimed in claim 43, wherein said second potential is more positive than said first potential.

45. An ion detector as claimed in claim 44, wherein the potential difference between said surface of said anode and said output surface of said one or more microchannel plates is selected from the group consisting of: (i) 0-50 V; (ii) 50-100 V; (iii) 100-150 V; (iv) 150-200 V; (v) 200-250 V; (vi) 250-300 V; (vii) 300-350 V; (viii) 350-400 V; (ix) 400-450 V; (x) 450-500 V; (xi) 500-550 V; (xii) 550-600 V; (xiii) 600-650 V; (xiv) 650-700 V; (xv) 700-750 V; (xvi) 750-800 V; (xvii) 800-850 V; (xviii) 850-900 V; (xix) 900-950 V; (xx) 950-1000 V; (xxi) 1.0-1.5 kV; (xxii) 1.5-2.0 kV; (xxiii) 2.0-2.5 kV; (xxiv) > 2.5 kV; and (xxv) < 10 kV.

46. An ion detector as claimed in claim 43, wherein said third potential is substantially equal to said first and/or said second potential.

47. An ion detector as claimed in claim 43, wherein said third potential is more positive than said first and/or said second potential.

250-300 V; (vii) 300-350 V; (viii) 350-400 V; (ix) 400-450 V; (x) 450-500 V; (xi) 500-550 V; (xii) 550-600 V; (xiii) 600-650 V; (xiv) 650-700 V; (xv) 700-750 V; (xvi) 750-800 V; (xvii) 800-850 V; (xviii) 850-900 V; (xix) 900-950 V; (xx) 950-1000 V; (xxi) 1.0-1.5 kV; (xxii) 1.5-2.0 kV; (xxiii) 2.0-2.5 kV; (xxiv) > 2.5 kV; and (xxv) < 10 kV.

49. An ion detector as claimed in claim 43, wherein said third potential is more negative than said first and/or said second potential.

50. An ion detector as claimed in claim 43, wherein said third potential is intermediate said first and second potentials.

51. An ion detector as claimed in claim 1, wherein said surface of said anode is arranged a distance x from the output surface of said one or more microchannel plates and wherein x is selected from the group consisting of: (i) < 5 mm; (ii) 5-10 mm; (iii) 10-15 mm; (iv) 15-20 mm; (v) 20-25 mm; and (vi) 25-30 mm mm.

52. An ion detector as claimed in claim 1, wherein said surface of said anode is arranged a distance x from the output surface and wherein x is selected from the group consisting of: (i) 35-40 mm; (ii) 40-45 mm; (iii) 45-50 mm; (iv) 50-55 mm; (v) 55-60 mm; (vi) 60-65 mm; (vii) 65-70 mm; (viii) 70-75 mm; and (ix) > 75 mm.

53. An ion detector for use in a mass spectrometer, said ion detector comprising:

one or more microchannel plates, wherein in use ions are received at an input surface of said one or more microchannel plates and electrons are released from an output surface of said one or more microchannel plates; and

an anode having a surface upon which electrons are received in use;

wherein said surface of said anode is arranged a distance x mm from said output surface and wherein x is selected from the group consisting of: (i) 35-40 mm; (ii) 40-45 mm; (iii) 45-50 mm; (iv) 50-55 mm; (v) 55-60 mm; (vi) 60-65 mm; (vii) 65-70 mm; (viii) 70-75 mm; and (ix) > 75 mm; and wherein said output surface has a first area and said surface of said anode has a second area.

54. An ion detector as claimed in claim 53, wherein said second area is 5-90% of said first area.

55. An ion detector as claimed in claim 54, wherein said second area is ≤ 85%, ≤ 80%, ≤ 75%, ≤ 70%, ≤ 65%, ≤ 60%, ≤ 55%, ≤ 50%, ≤ 45%, ≤ 40%, ≤ 35% or ≤ 30% of said first area.

56. An ion detector as claimed in claim 54, wherein said second area is ≤ 25%, ≤ 20%, ≤ 15% or ≤ 10% of said first area.

57. An ion detector as claimed in claim 54, wherein said second area is ≥ 10%, ≥ 15%, ≥ 20% or ≥ 25%, of said first area.

58. An ion detector as claimed in claim 54, wherein said second area is ≥ 30%, ≥ 35%, ≥ 40%, ≥ 45%, ≥ 50%, ≥ 55%, ≥ 60%, ≥ 65%, ≥ 70%, ≥ 75%, ≥ 80% or ≥ 85%.

59. An ion detector as claimed in claim 53, wherein said anode comprises a pin anode.

60. An ion detector for use in a mass spectrometer, said ion detector comprising:

one or more microchannel plates, wherein in use ions are received at an input surface of said one or more microchannel plates and electrons are released from an output surface of said one or more microchannel plates, said output surface having a first area; and

an anode having a surface upon which electrons are received in use, wherein the surface of said anode has a second area;

wherein said second area is 5-25% of said first area.

61. An ion detector as claimed in claim 60, wherein said second area is ≤ 20%, ≤ 15% or ≤ 10% of said first area.

62. An ion detector for use in a mass spectrometer, said ion detector comprising:

one or more microchannel plates, wherein in use ions are received at an input surface of said one or more microchannel plates and electrons are released from an output surface of said one or more microchannel plates, said output surface having a first area; and

an anode having a surface upon which electrons are received in use, wherein the surface of said anode has a second area;

wherein said second area is 30-90% of said first area.

63. An ion detector as claimed in claim 62, wherein said second area is ≥ 30%, ≥ 35%, ≥ 40%, ≥ 45%, ≥ 50%, ≥ 55%, ≥ 60%, ≥ 65%, ≥ 70%, ≥ 75%, ≥ 80% or ≥ 85% of said first area.

64. An ion detector as claimed in claim 60, wherein said surface of said anode is arranged a distance x mm from said output surface and wherein x is selected from the group consisting of: (i) < 5 mm; (ii) 5-10 mm; (iii) 10-15 mm; (iv) 15-20 mm; (v) 20-25 mm; and (vi) 25-30 mm.

65. An ion detector as claimed in claim 60, wherein said surface of said anode is arranged a distance x mm from said output surface and wherein x is selected from the group consisting of: (i) 35-40 mm; (ii) 40-45 mm; (iii) 45-50 mm; (iv) 50-55 mm; (v) 55-60 mm; (vi) 60-65 mm; (vii) 65-70 mm; (viii) 70-75 mm; and (ix) > 75 mm.

66. An ion detector as claimed in claim 1, wherein electrons may be received across substantially the whole of said second area.

67. An ion detector as claimed in claim 1, wherein said anode comprises a first portion, a second portion and an electrically insulating layer provided between said

first and second portions, said first portion having a surface upon which electrons are received in use.

68. An ion detector as claimed in claim 67, wherein in use said first portion is maintained at a different DC potential to said second portion.

69. An ion detector as claimed in claim 67, wherein in use said first portion is maintained at substantially the same DC potential as said second portion.

70. An ion detector as claimed in claim 1, wherein said anode is substantially conical.

71. An ion detector as claimed in claim 70, further comprising a substantially conical screen surrounding at least a portion of said anode.

72. An ion detector as claimed in claim 1, wherein said anode has a capacitance selected from the group consisting of: (i) 0.01-0.1 pF; (ii) 0.1-1 pF; (iii) 1-10 pF; and (iv) 10-100 pF.

73. An ion detector as claimed in claim 1, wherein said surface of said anode upon which electrons are received in use is substantially flat.

74. A mass spectrometer comprising an ion detector as claimed in claim 1.

75. A mass spectrometer as claimed in claim 74, wherein said ion detector is arranged in a Time of Flight mass analyser.

76. A mass spectrometer as claimed in claim 75, wherein said Time of Flight mass analyser comprises an axial Time of Flight mass analyser.

77. A mass spectrometer as claimed in claim 75, wherein said Time of Flight mass analyser comprises an orthogonal acceleration Time of Flight mass analyser.

78. A mass spectrometer as claimed in claim 75, wherein said Time of Flight mass analyser further comprises a reflectron.

79. A mass spectrometer as claimed claim 74, further comprising an Analogue to Digital Converter ("ADC") connected to said ion detector.

80. A mass spectrometer as claimed in claim 74, further comprising a Time to Digital Converter ("TDC") connected to said ion detector.

81. A mass spectrometer as claimed in claim 74, further comprising an ion source selected from the group consisting of: (i) an Atmospheric Pressure Chemical Ionisation ("APCI") ion source; (ii) an Atmospheric Pressure Photo Ionisation ("APPI") ion source; (iii) a Laser Desorption Ionisation ("LDI") ion source; (iv) an Inductively Coupled Plasma ("ICP") ion source; (v) a Fast Atom Bombardment ("FAB") ion source; (vi) a Liquid Secondary Ion Mass Spectrometry ("LSIMS") ion source; (vii) a Field Ionisation ("FI") ion source; (viii) a Field Desorption ("FD") ion source; (ix) an Electron

Impact ("EI") ion source; and (x) a Chemical Ionisation ("CI") ion source.

82. A mass spectrometer as claimed in claim 74, further comprising a Matrix Assisted Laser Desorption Ionisation ("MALDI") ion source.

83. A mass spectrometer as claimed in claim 74, further comprising an Electrospray ion source.

84. A mass spectrometer as claimed in claim 81, wherein said ion source is continuous.

85. A mass spectrometer as claimed in claim 81, wherein said ion source is pulsed.

86. A method of detecting ions comprising:

receiving ions at an input surface of one or more microchannel plates;

releasing electrons from an output surface of said one or more microchannel plates; and

directing, guiding or attracting at least some of said electrons released from said one or more microchannel plates onto a surface of an anode by means of one or more electrodes and/or one or more magnetic lenses, wherein the area of said surface of said anode is ≥ 5% of the area of said output surface of said one or more microchannel plates.

87. A method of detecting ions comprising:

receiving ions at an input surface of one or more microchannel plates;

releasing electrons from an output surface of said one or more microchannel plates; and

directing or guiding at least some of said electrons released from said one or more microchannel plates onto a surface of an anode by means of one or more electro-magnets and/or one or more permanent magnets.

88. A method of detecting ions comprising:

receiving ions at an input surface of one or more microchannel plates;

releasing electrons from an output surface of said one or more microchannel plates;

directing, guiding or attracting at least some of said electrons released from said one or more microchannel plates onto a surface of an anode by means of a plurality of electrodes and/or one or more magnetic lenses.

89. A method of detecting ions comprising:

receiving ions at an input surface of one or more microchannel plates;

releasing electrons from an output surface of said one or more microchannel plates; and

directing at least some of said electrons released from said one or more microchannel plates onto a surface of an anode, wherein said surface of said anode is arranged a distance x mm from said output surface and wherein x is selected from the group consisting of: (i) 35-40 mm; (ii) 40-45 mm; (iii) 45-50 mm; (iv) 50-55 mm; (v) 55-60 mm; (vi) 60-65 mm; (vii) 65-70 mm; (viii) 70-75 mm; and (ix) > 75 mm.

90. A method of detecting ions comprising:

receiving ions at an input surface of one or more microchannel plates;

releasing electrons from an output surface of said one or more microchannel plates; and

directing at least some of said electrons released from said one or more microchannel plates onto a surface of an anode, wherein the area of said surface of said anode is 5-25% of the area of said output surface of said one or more microchannel plates.

91. A method of detecting ions comprising:

receiving ions at an input surface of one or more microchannel plates;

releasing electrons from an output surface of said one or more microchannel plates; and

directing at least some of said electrons released from said one or more microchannel plates onto a surface of an anode, wherein the area of said surface of said anode is 30-90% of the area of said output surface of said one or more microchannel plates.

92. A method of mass spectrometry comprising a method of detecting ions as claimed in claim 86.